Strongman Log Push Press: The Effect Log Diameter has on Force-Time Characteristics

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INTRODUCTION

Push pressing with a strongman log is being increasingly included in athlete strength and conditioning programs and in research (12,13,14,15). The principal reason for this is that it is thought that it makes greater mechanical demands on the athlete in terms of mid-section and shoulder girdle stability. However, very little is known about the force-time characteristics of the log push press. This represents a shortfall in the strength and conditioning literature as it is important for this type of information to be available to both practitioners and athletes so that they can make informed decisions about whether and/or how to include an exercise in their programs.

We know that while barbell push press peak power is comparable with that of the loaded jump squat, push press mean power is significantly greater (7). Furthermore, while impulse applied to the barbell and the body's center of mass during the jump squat with a load that maximized peak power was significantly greater than the push press equivalent, there were no significant differences between the impulse applied during push press and jump squat with the load that maximized mean power. This is important because it highlights that the push press could provide a time effective lower-body power, upper-body press, and whole body stabilizing exercise, particularly when combined with the power clean. This may be particularly important during the in season phase many athletes, whereby the frequency and volume of resistance training may be reduced due to the greater demands of competition and sport specific skills and tactical training requirements.

In addition to the above, investigators have compared some key force-time characteristics of barbell and log push press (12). They found that the barbell elicited larger force, velocity, power and impulse throughout the dip and push press/jerk phases. When isolating the push press/jerk phase, the barbell was 12% faster (peak velocity), and had a 34% larger peak power, and a 35% larger mean power when

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compared to the log; this was driven by a 13% larger impulse (12). However, it is important to note that participants were allowed to use either the push press or push jerk technique in this study, and that a small (165 mm diameter log was used). This isn't the only size of log that is commercially available and it is not typically used in competition. While this study provides useful information, it does make it difficult to isolate the push press phase, the individual phases within the push press, whether participants used a push press or push jerk technique, and how much of the difference may be due to the different grip styles adopted because of the log's dimensions. A larger diameter log (330 mm diameter) would cause the lifter to hold the load further away from the center of mass which would not only change the lifter's body position, but may impact how lifters adapt their pressing technique.

Research aside, it should be noted that there are inconsistencies with the size of the logs that can be used in training and competition. The only guidelines that have been provided about the size of the logs used for strongman competition came from former International Federation of Strength Athletes (IFSA). It should also be noted that the dimensions they proposed are much larger than the dimensions used previously in the literature analyzing the force-time characteristics of log push press exercise. Therefore, there is a need to improve our understanding the force-time characteristics of log push press by investigating the effects of varying size logs seen in Figure 1.

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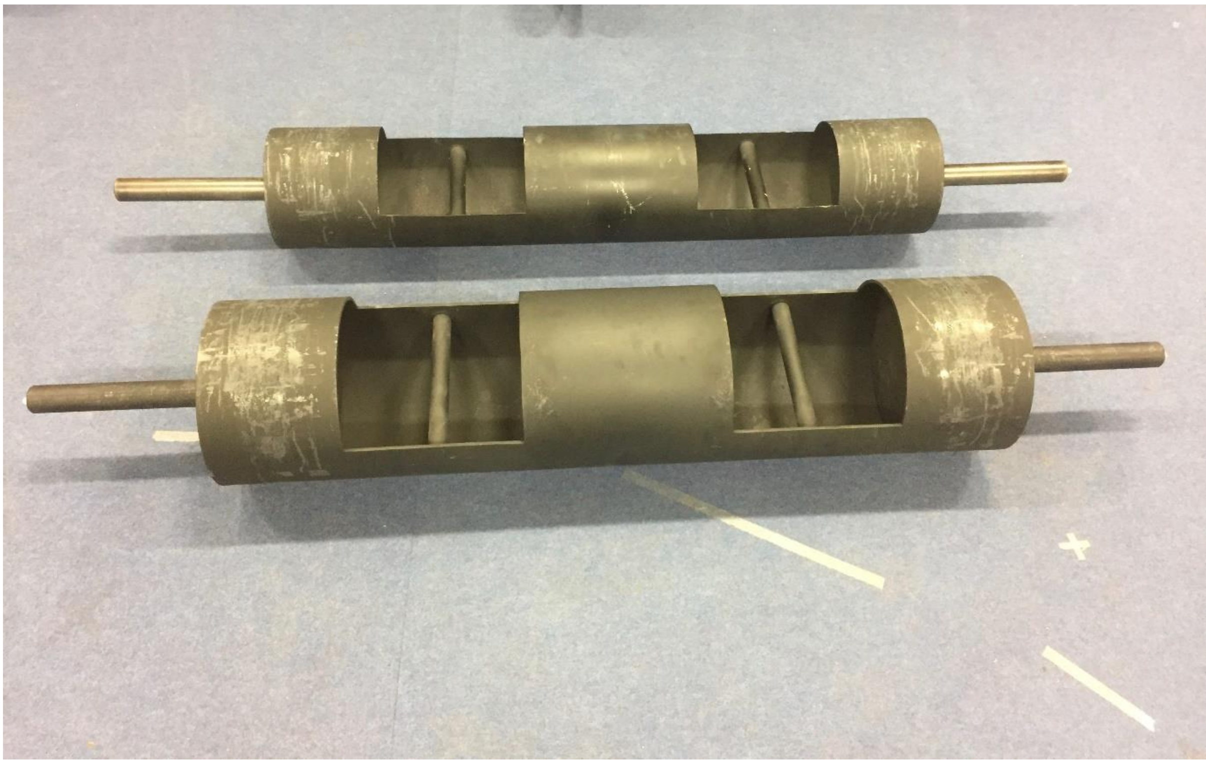

Figure 1: Image of the 2 different sized logs used in the testing.

Therefore, the aim of this study was to compare the force-time and temporal characteristics of push press exercise with a barbell, small log, and big log. It was hypothesized that 1) the force-time characteristics, like impulse, mean force, and mean power of the barbell push press will be significantly greater than the big and small log push press, but that there will be no significant differences between the small and big log push press and 2) there will be no significant differences in the displacement and duration of barbell, small or big log push press.

METHOD

Experimental Approach to the Problem

Experienced strongman competitors familiar with the rack push press using both a barbell, small log and big log participated in this within-subject repeated measures design. Subjects regularly tested their one repetition maximum (1RM) as part of their training program and had all tested this within three weeks of the study. Subjects performed the push press with the barbell, small log and big log from a rack (Figure 2) on the same day, in a randomized order. The performance parameters of mean braking and propulsion phase force, velocity, power and power were derived from vertical force data obtained from two force platforms each capturing vertical force at 1000 Hz.

Subjects

Ten healthy men, five competing in strongman at an amateur level (where athletes register to compete in regional and national strongman competitions) and five at a semi-professional level (where athletes are selected to compete both nationally and internationally for their country of origin) from under 90 kg to open categories (>105 kg) volunteered to participate (Table 1). Their mean (SD) age was 29.80 (3.68) years with a minimum of two years' strongman training and competition experience; they trained a minimum of three days per week. All subject utilized the log push press as part of their regular routine and were familiar with the rack barbell and log push press exercise. Subjects read an information sheet, completed a health history questionnaire and provided informed consent; ethical approval was granted from the institutional ethics board before data collection.

Procedure

Subjects completed a self-selected dynamic warm up that was based on their specific strength training and competition routine and these varied from subject to subject. They attended one laboratory-based session where they performed three single effort push presses with the barbell, small log and big log from a free-standing rack (Figure 2). The barbell, small and big logs were loaded with 65% of their barbell push press 1RM. The barbell push press was performed with a standard 20 kg Olympic barbell (2.2 m long), while the log push press was performed with a small log (250 mm in diameter, 1400 mm long, handles 620 mm apart, with 290 mm wide cut outs), and a large (IFSA specification) log (big log), (316 mm in diameter, 1400 mm long, handles 620 mm apart, with 290 mm wide cut outs).

Each lift was separated by a minimum rest period of 1 minute and a maximum rest period of 5 minutes (9). Following their warm up, subjects were provided with a 5-10 minutes familiarization period with the unloaded implements before testing.

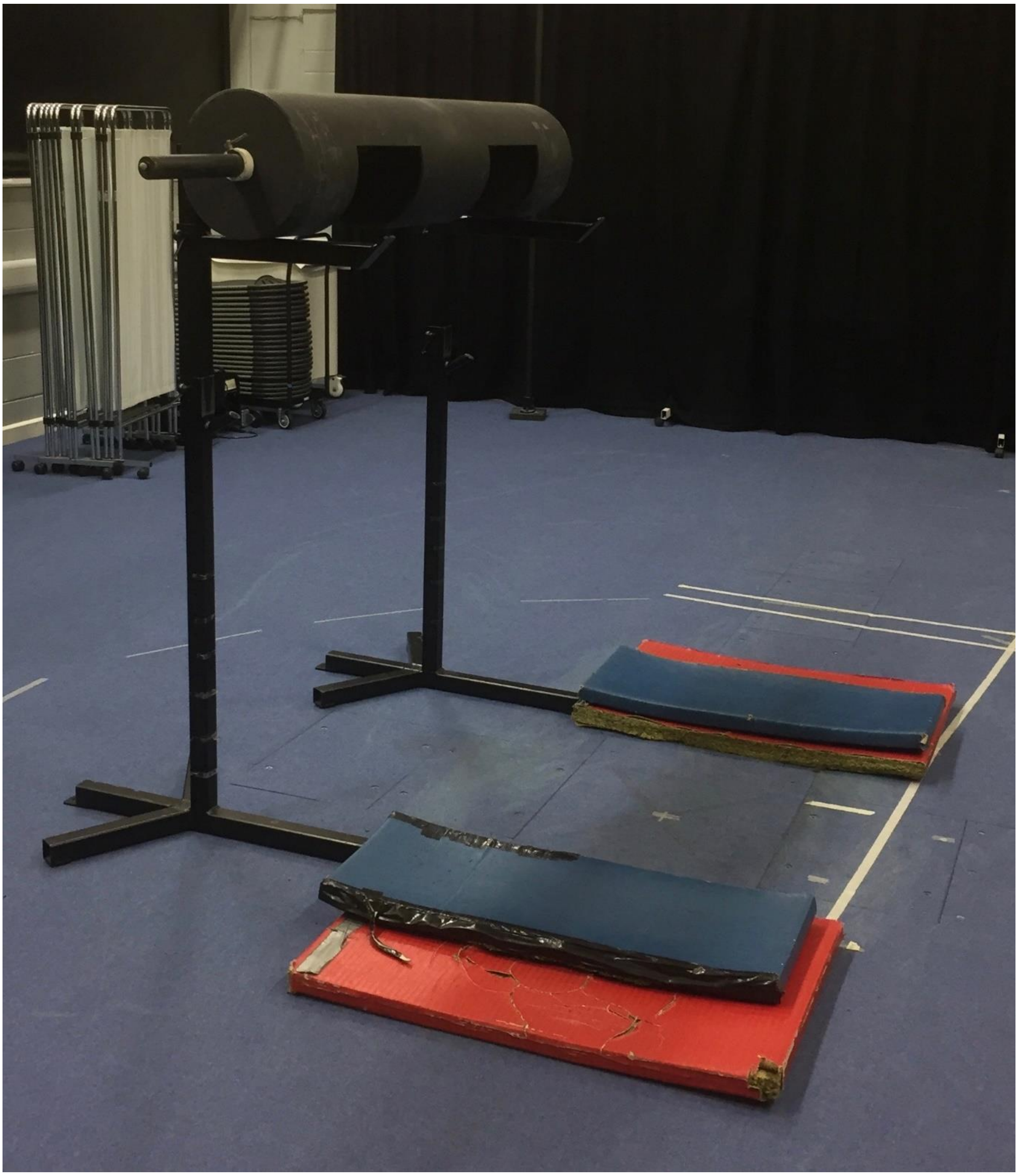

Figure 2: Image of rack set up for testing.

A total of nine trials were recorded from each subject. Vertical ground reaction force data was recorded from two force plates (one foot on each plate) (Type 9851B, Kistler Instruments Ltd., Hook, UK) synchronously at 1000 Hz using VICON Nexus (Version 1.7.1; Vicon Motion Systems Ltd., Oxford, UK); left and right side vertical forces were summed for the initial part of data analysis.

Table 1. Mean (±SD) subject physical characteristics and training experience.

Demographic and training experience	Mean ± SD
Age (years):	29.80 ± 3.68
Height (cm):	183.52 ± 6.31
Mass (kg):	116.04 ± 16.88
Weight (N):	1138.35 ± 165.55
Resistance training experience (years):	9.70 ± 5.70
Strongman training experience (years):	4.45 ± 2.61
Number of sessions (per week):	4.30 ± 0.95
Average training time per session (mins):	99 ± 20.25
Log push press 1RM (kg):	145.45 ± 10.29
Barbell push press 1RM (kg):	145.70 ± 9.63
Barbell push press 65% 1RM (kg):	94.71 ± 6.26
Barbell push press 1RM relative to body mass:	1.28 ± 0.22
Squat 1RM (kg):	244.50 ± 20.20
Squat 1RM relative to body mass:	2.10 ± 0.30

The Exercise

The push press technique was based on the description provided by Waller et al. (11) and the jerk technique was not permitted. To standardize the starting position, subjects were instructed to keep their upper arm/humerus positioned parallel to the ground (or as close as they could within anatomical constraints). When using the small and big logs, subjects were advised to have their little finger in the highest position whilst maintaining a strong grip on the log.

Statistical Analyses

The dependent variables of mean vertical braking and propulsion force, velocity, power, and impulse, dip and propulsion displacement and propulsion and total duration were derived from vertical force using the methods describe by Lake et al. (7) (Figure 3). The independent variables were the pressing implements (barbell, small log, and big log). Briefly, data were analyzed using a customized spreadsheet to obtain the dependent variables. Mean force, velocity and power were obtained by averaging force, velocity, and power over the braking and propulsive phases, respectively. Power was calculated as the product of force applied to and velocity of the center of mass. Velocity of the center of mass (CoM) was obtained by subtracting barbell (or log)-and-body weight from vertical force before dividing it by barbell (or log)-and-body mass, and then integrating the product using the trapezoid rule. Impulse was obtained from the area under the net force-time curve (force minus barbell (or log)-and-body weight) during the braking and propulsive phases using the trapezoid rule. The braking and propulsive phases were identified from the velocity-time curve. The braking phase began at the lowest countermovement velocity and ended at the velocity transition from negative to positive. This post countermovement transition from negative to positive velocity plus 1 sample marked the beginning of the propulsion phase, which ended at peak velocity. Displacement was calculated by integrating the velocity-time curve with respect to time, and then phase durations were calculated (7).

After the assumption that data were normally distributed was confirmed, repeated measures one-way analysis of variance (ANOVA), using an alpha level of $p \leq 0.05$ were used to explore the effect that the implement had on the dependent variables. All statistical analyses were performed using SPSS (IBM SPSS Statistics, Version 23.0). If Mauchley's test of sphericity was significant, the Greenhouse-Geisser correction was used to obtain the F-value. Follow up paired sample *t* tests were performed for further analysis where appropriate applying the Bonferroni correction. Effect sizes were calculated by subtracting mean_2 (e.g. small log) from mean_1 (e.g. barbell) and dividing the result by their pooled SD, and Cohen's applied descriptors of >0.2, >0.5 and >0.8 to categorize a small, moderate and large effect were used to quantify their magnitude.

RESULTS

Subject characteristics are presented in Table 1. This shows that all subjects had a push press to body mass ratio of 1.28 (± 0.22), in addition to having a barbell push press 1RM relatively equal to their log push press 1RM (log size not specified, p = 0.637). All subjects trained on average for the same amount of time per session (99 ± 20.25 minutes), with varying resistance training (9.70 ± 5.70 years) and strongman training and competition (4.45 ± 2.61 years) experience.

Impulse, force, velocity, and power

The implement used to perform the push press exercise significantly affected braking phase impulse ($F_{(2,18)} = 13.907$, p <0.001, 1-β = 0.994), mean force ($F_{(2,18)} = 8.080$, p

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= 0.003, 1-β = 0.890), mean velocity ($F_{(2,18)}$ = 14.942, p <0.001, 1-β = 0.997) and mean power ($F_{(2,18)}$ = 16.078, p <0.001, 1-β = 0.998) (Table 2). Barbell push press braking impulse (small log: p = 0.019, d = 0.52; big log: p <0.001, d = 0.89), mean force (small log: p = 0.064, d = 0.33; big log: p = 0.003, d = 0.53), mean velocity (small log: p = 0.005, d = 0.85; big log: p < 0.001, d = 1.24) and mean power (small log: p = 0.008, d = 0.51; big log: p <0.001, d = 0.83) was significantly greater than the small and big log equivalents. There were no significant differences between small log and big log for these variables (p >0.05, d = 0.21 to 0.39).

Table 2. Mean (±SD) push press braking parameters.

	Barbell	Small log	Big log
Braking Impulse (Ns)	130.50± 27.29*†	116.05± 28.73	106.04± 27.83
Braking Force (N)	775.38± 316.85†	680.13± 262.43	625.12± 251.90
Braking Velocity (m/s)	-0.40± 0.05*†	-0.36± 0.06	-0.33± 0.06
Braking Power (W)	-1087.34± 283.43*†	-943.26± 280.97	-854.09± 275.88

*Significant difference between barbell and small log (p <0.05); † significant difference between barbell and big log (p <0.05)

The implement used to perform push press exercise significantly affected propulsion phase impulse ($F_{(2,18)}$ = 45.094, p <0.001, 1-β = 1.000), mean force ($F_{(2,18)}$ = 10.455, p <0.001, 1-β = 0.963), mean velocity ($F_{(2,18)}$ = 57.892, p <0.001, 1-β = 1.000) and mean power ($F_{(2,18)}$ = 31.804, p <0.001, 1-β = 1.000) (Table 3). Furthermore, barbell push press propulsion impulse (small log: p <0.001, d = 0.97; big log: p <0.001, d = 1.51), mean force (small log: p = 0.035, d = 0.39; big log: p <0.001, d = 0.63), mean velocity (small log: p <0.001, d = 1.40; big log: p <0.001, d = 1.93) and mean power (small log: p <0.001, d = 1.00; big log: p <0.001, d = 1.47) was significantly greater than the small and big log equivalents. There were no significant differences between small log and big log for these variables (p >0.05, d = 0.28 to 0.43).

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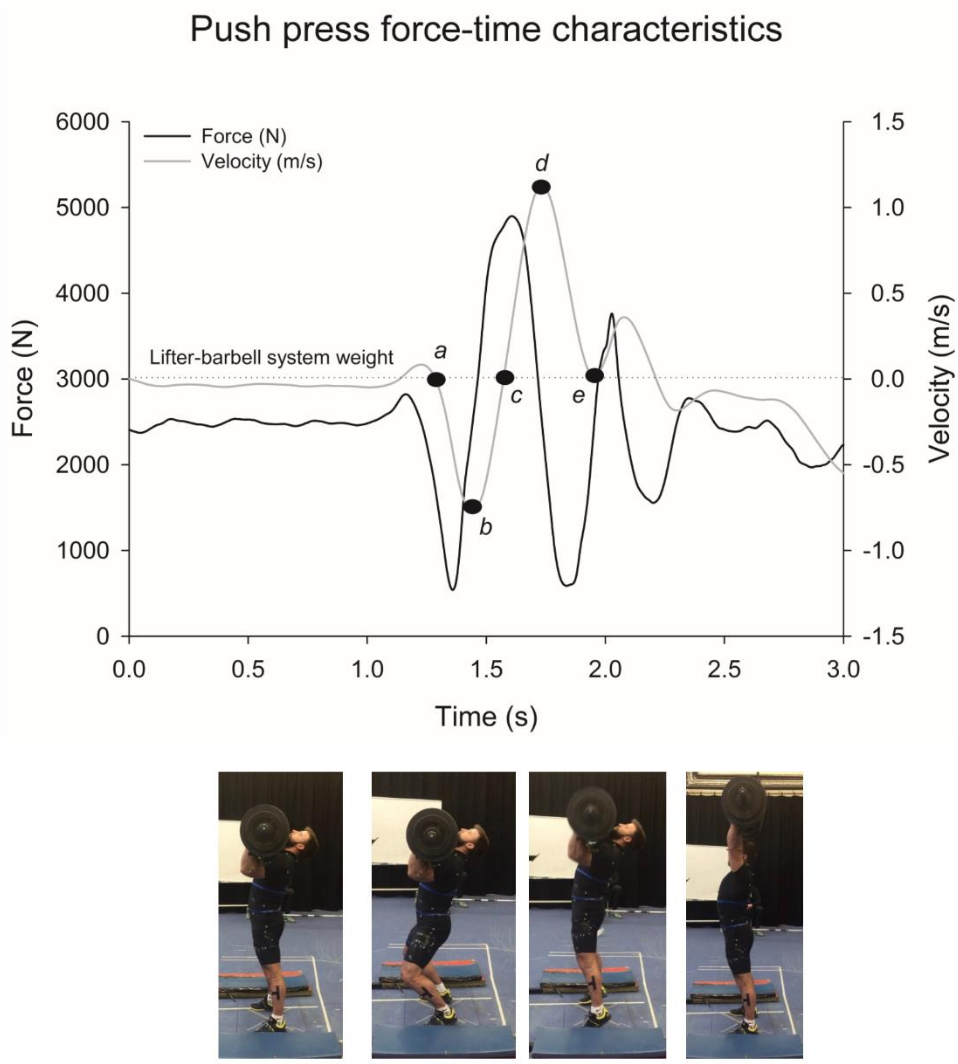

Start to 'a' - Standing still with barbell in rack position

'a' to 'b' - Unweighting phase - negative acceleration, negative direction

'b' to 'c' - Eccentric braking phase - positive acceleration, negative direction

'c' to 'd' - Concentric propulsion phase - positive acceleration, positive direction

'd' to 'e' - Concentric propulsion phase - negative acceleration, positive direction

'e' to end - Standing still with barbell overhead

Figure 3: Image of the separate phases analyzed in the push press movement.

Table 3. Mean (±SD) push press propulsion parameters.

	Barbell	Small log	Big log
Propulsive Impulse (Ns)	293.08 ± 40.04*†	254.89 ± 38.79	241.19 ± 28.67
Propulsive Force (N)	3399.02 ±492.02*†	3232.74 ± 356.73	3131.29 ± 362.65
Propulsive Velocity (m/s)	0.74 ± 0.07*†	0.64 ± 0.07	0.62 ± 0.06
Propulsive Power (W)	2469.00 ± 481.85*†	2040.56 ± 376.70	1896.64 ± 295.12

*Significant difference between barbell and small log (p <0.05); † significant difference between barbell and big log (p <0.05)

Displacement and time Parameters

The implement used to perform the push press exercise significantly affected dip phase displacement ($F_{(2,18)}$ = 8.163, p = 0.003, 1-β = 0.894) and propulsion phase displacement ($F_{(2,18)}$ = 30.452, p <0.001, 1-β = 1.000) (Table 4). Barbell dip displacement was significantly greater than the small log (p = 0.035, d = 0.77) and big log (p = 0.003, d = 1.16) equivalents, while there were no significant differences between small log and big log dip displacement (p = 0.832, d = 0.39). Barbell propulsion displacement was significantly greater than the small log (p <0.001, d = 0.97) and big log (p <0.001, d = 1.22) equivalents. The implement used to perform push press exercise did not significantly affect propulsion ($F_{(2,18)}$ = 0.730, p = 0.496, 1-β = 0.049) or total performance time ($F_{(2,18)}$ = 0.241, p = 0.788, 1-β = 0.050) (Table 4).

Table 4. Displacement and time parameters of push press.

	Barbell	Small log	Big log
Dip Displacement (m)	-0.17 ± 0.04*†	-0.14 ± 0.03	-0.13 ± 0.02
Propulsion Displacement (m)	0.17 ± 0.03*†	0.14 ± 0.02	0.14 ± 0.02
Propulsion Duration (secs)	0.22 ± 0.03	0.22 ± 0.02	0.22 ± 0.02
Total Duration (secs)	0.54 ± 0.47	0.67 ± 0.06	0.64 ± 0.07

*Significant difference between barbell and small log (p <0.05); † significant difference between barbell and big log (p <0.05)

DISCUSSION

The aim of this study was to compare the force-time and temporal characteristics of push press exercise with a barbell, small log and big log in experienced strongman athletes. It was hypothesized that 1) the force-time characteristics, like impulse, mean

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force, and mean power of the barbell push press would be significantly greater than the big and small log push press, but that there would be no significant differences between the small and big log push press and 2) there would be no significant differences in the displacement and duration of barbell, small or big log push press. This study builds on the work done by Winwood et al. (12) by recruiting a higher standard of athlete, deconstructing the push press into its braking and propulsion phases, and by studying two different size logs.

With regards to the primary aim, in nearly all cases barbell impulse, mean force, and mean power was significantly and meaningfully larger during the barbell push press; therefore, the first hypothesis was accepted. However, it should be noted that the difference between the barbell and small log mean force during the braking phase was not statistically significant and the effect size indicated a small effect (12%, $d = 0.33$). Overall the current findings support the findings by Winwood et al. (12) who showed the barbell elicits significantly (~15%, $p < 0.05$) greater braking and propulsion phase mean force, power, velocity and impulse compared to both strongman logs. It was also interesting to observe that the small log elicited a 14% reduction in mean propulsion velocity, while the big log elicited an 18% reduction mean propulsion velocity compared to the barbell where previous research found a 10% reduction during push press (12). However, the difference reported by Winwood et al. (12) was obtained with subjects lifting a smaller diameter log (165 mm) than used in the current study, suggesting that mean propulsion velocity appears to decrease in proportion to the size of the log used. The same trend was also seen with force and power, showing an 18% reduction in power with the small log, and 24% with the big log unlike the 40% found previously (12). However, this may be due to subjects being able to use either the push press or jerk technique in previous research, which could account for the increase found in the current investigation. The reduction in all performance parameters when using the log suggests there is a higher mechanical demand with this exercise relative to the barbell which increases the larger the diameter of the log. Considering this in a practical training context, this could imply that if an athlete trains within certain parameters, for example optimal power ranges, they may need to reduce the working load depending on the size of log. However, further investigations will be needed to clarify this.

The braking phase analyzed in this study isolates the eccentric component of the push press (the point at which the elastic energy storage is retained for use during the propulsion phase) and the results show that the propulsion phase has a higher output in comparison to the braking phase for all dependent variables. Compared to the braking phase, the propulsion phase was 4.4 times greater in force, 2.2 times in impulse, 1.8 times in velocity and 2.3 times in power, with this becoming more pronounced the larger the diameter the log. This highlights the importance of focusing on concentric strength training if the athlete's aim is to improve their performance in the log press especially with a larger diameter log - the larger the log the greater the biomechanical demands. The resulting difference between braking and propulsion phases may additionally highlight the importance of optimizing the braking phase to improve propulsion output, however further research is needed for clarity.

The results of this study also showed a significant difference (p = 0.05) between the propulsion phase for the small log and big log; revealing the small log has a 6% mean difference in propulsion phase power, 2% velocity, 5% impulse and 3% force in comparison to the big log (d ≤0.42) but there was no difference in displacement and lift duration. This suggests that the closer a load is to the athletes CoM (as found with a smaller diameter implement), the higher the propulsion output that can be achieved. As there was relatively little difference between the two log diameters, this may also suggest that the physiological and mechanical systems may absorb the additional stresses of the larger diameter of the big log. This may explain the lack of difference between barbell and log push press displacement and duration. However, it is not known if this trend continues with a larger diameter log or heavier loads, or whether it is underpinned by log grip styles (orientation and width).

With regards to the dip and propulsion displacement parameters, the barbell enabled the subjects to utilize a significantly larger displacement compared to both size logs with no significant difference in duration. This suggests that higher forces are achieved with larger displacement, which is consistent with previous findings (7) that compared power output between BB push press and jump squat; it suggests that there may be an optimal time or tissue length component to maximize elastic energy storage. These results may suggest that in order to improve performance with a large diameter log, the athlete needs to generate higher force in a smaller range of lower-body movement.

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One explanation to the relative inability to utilize a large dip displacement when using the logs, may be the increased thoracic and/or lumbar extension required to hold the log in the static hold phase which potentially alters the athletes CoM and base of support, positioning it more posteriorly. This reduction in stability which may result in increased core muscular activity may or may not underpin the reduced vertical displacement and could explain the abdominal electromyographical results presented by McGill et al. (8). Winwood et al (12) did show that the log requires significant posterior trunk lean throughout the push press/jerk phase along with a non-significant increase in dip displacement time; further biomechanical and electromyographical studies are required to understand this further.

Between the braking and propulsion phase parameters (Table 2, 3 & 4) the results showed high variability. This is evidenced by the large standard deviations and whether this is due to the exercise itself, the normal variation that occurs when individuals get to the level of experience in strongman, the subtle variation in lifting styles adopted by the subjects due to lift style preference and/or the athletes' biomechanical capacity is unclear and requires further research. Another explanation for the variability may be due to whether the load was the participants true 65% 1RM on the day of testing, as day to day variability has been shown in lift ability by studies analyzing velocity based versus traditional methods of assessing 1RM (1-3). However, as all subjects in the current study lifted the same relative load on each implement, it is unlikely that this would have impacted our results. Given the experience of all participants these findings may be normal for the push press exercise in strongman athletes.

Future areas of research into the whole-body kinematics of the barbell and log push press may include the effect due to variation of grip (handle) position which may change upper-limb lifting biomechanics. Shoulder biomechanical variances have already been demonstrated with respect to the scapular and clavicular kinematics in the military press compared to shoulder flexion with and without load (5) in addition with differences in muscle activity seen at different ranges of the military press exercise (10). Further analysis of what occurs at loads more and less than 65% 1RM, whether there are variations within different weight categories (as anecdotally the under 90 kg category are more mobile in comparison to the open/heavier strongman

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athletes), and whether experience dictates this variation (as it has been demonstrated the more experienced lifters have a shorter braking phase in the weightlifting jerk exercise (4)) could all assist in improving the understanding of this exercise.

To conclude, this study is the first to provide information on the difference in the braking and propulsive performance parameters between the barbell and varying sizes of strongman log focusing entirely on the push press exercise. It showed that there is a significant difference between the barbell and different size log performance parameters. The big log appears to require a higher mechanical demand as all propulsive variables were lower than the barbell and this is most likely due to having the barbell closer to the participants CoM providing a more stable base of support, thus providing an advantage to the whole-body biomechanics to output higher forces.

PRACTICAL APPLICATIONS

The practical applications of this study suggest that if the athlete or coach aims to maximize force, power, velocity and impulse in the push press, the barbell is superior when compared to the small and big strongman log. Additionally, the evidence suggests these exercises have a greater relative propulsion phase demand when compared to the braking phase demand. When utilizing the strongman log, the results show that they appear to make a larger mechanical demand when compared to the barbell. This is because lower force outputs achieved during both braking and propulsion phases and that this effect is more pronounced with the larger the log diameter. This may be a useful tool if the aim is to improve the athlete’s physical conditioning. In contrast, the higher demand may induce earlier onset fatigue if a barbell is normally used; there was an inverse trend as the larger the diameter strongman log the greater the reduction in force output (12% in braking and 5% propulsion force output comparing small log to barbell and 20% for braking and 8% for propulsive force with barbell to big log). Specifically for strongman athletes, if competitors are uncertain of the size of log in competition the results suggest that training with a larger log may be more helpful for competition preparation as the mechanical requirements are higher than a smaller diameter log. It is also worth noting that when utilizing optimal power parameters in training, which has been found to be 65% of the athletes push press 1RM, the load may have to be reduced by 18% for a small log and 24% for a big log to optimize this due to the increased mechanical

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demands the log makes compared to the barbell. However, further investigation is needed. From a rehabilitation perspective, the log push press offers the potential to maintain conditioning with this exercise and upper-body strength if the athlete finds it difficult to attain the desired barbell push press positions.

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